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(54) **GAS-LIQUID SEPARATOR, COMPRESSOR ASSEMBLY AND AIR CONDITIONER**

(57) A gas-liquid separator (100), comprising a housing, an outlet pipe (103), and a liquid suction pipe (104). The outlet pipe (103) passes through a side wall of the housing to reach an outside of the housing. One end of the liquid suction pipe (104) extends to a bottom of an inner cavity of the gas-liquid separator (100), and another end of the liquid suction pipe (104) is connected to the outlet pipe (103). Also disclosed are a compressor assembly and an air conditioner. By means of shortening the length of the outlet pipe (103), the first-order resonance frequency of a refrigerant may be increased to prevent the air suction frequency of a compressor from significantly exceeding the first-order resonance frequency of the refrigerant when operating at a high frequency, which thereby facilitates the compressor in generating an intake pressure boost effect when operating at the high frequency, enhances the air intake efficiency of the compressor, and improves the performance of the compressor.

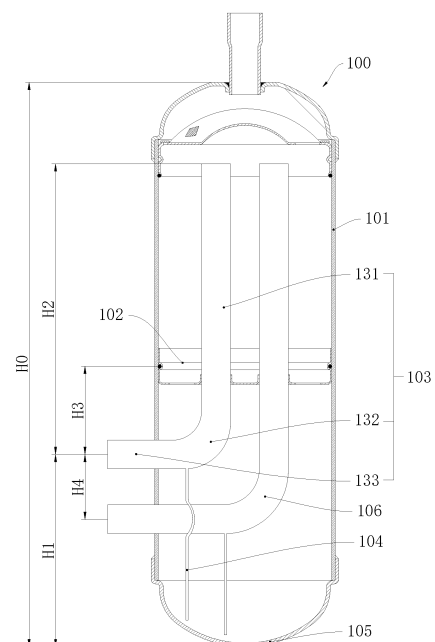


FIG. 3

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Description

CROSS-REFERENCE TO RELATED APPLICATION

5 [0001] This application claims priority to Chinese Patent Application No. 201910188182.2, submitted with Chinese Patent Office on March 13, 2019, entitled "Gas-Liquid Separator, Compressor Assembly and Air Conditioner".

TECHNICAL FIELD

10 [0002] The present application relates to a field of air conditioning technology, in particular, to a gas-liquid separator, a compressor assembly, and an air conditioner.

BACKGROUND

15 [0003] In the prior art, it is known that a compressor utilizes an intake pressure boost effect. Since the compressor periodically draws gas from a gas-liquid separator, refrigerant in the gas-liquid separator forms periodic pulsation. When a pulsation frequency of the refrigerant reaches an intake resonance, an amplitude of the pulsation of the refrigerant in the gas-liquid separator reaches the maximum. The intake frequency of this type of compressor is equivalent to the intake resonance frequency (the intake frequency of the compressor is generally not greater than the intake resonance frequency), a pressure wave generated by the resonance of the refrigerant produces the intake pressure boost effect on the intake of the compressor, which in turn increases the amount of refrigerant sucked into the compressor, and enhances the compression performance of the compressor.

20 [0004] A Chinese patent application with publication No. CN107002655A describes a calculation expression of a resonant peak rotational speed (intake resonant frequency) of a compressor that can achieve the intake pressure boost effect. That is, a first-order resonance frequency f of the refrigerant can be calculated by the expression $f=C/\{4[L+(V/A)]\}$. In the expression, C denotes a speed of sound transmitting in the refrigerant (m/s), L denotes a length of an outlet pipe through which the refrigerant flows (m), V denotes a displacement of the compressor (m³), and A denotes a cross-sectional area of the outlet pipe (m²).

25 [0005] However, the conventional compressors are developing toward higher and higher compression frequencies. That is, the intake frequency of the compressor is getting higher and higher, which causes the intake frequency of the compressor to exceed the intake resonance frequency, resulting in that the compressor cannot use the resonance pulsation of the refrigerant to achieve the intake pressure boost effect during the gas suction. Therefore, the amount of the intake in the compressor is reduced, resulting in the deterioration of the performance of the compressor.

30 [0006] It can be seen from the expression of the first-order resonance frequency f of the refrigerant that the first-order resonance frequency f of the refrigerant may be increased by reducing the length L of the outlet pipe and the displacement V of the compressor, or increasing the cross-sectional area A of the outlet pipe. Changes in the displacement V of the compressor and the cross-sectional area A of the outlet pipe have a relative small influence on the first-order resonance frequency f of the refrigerant. The length L of the outlet pipe has a relative large influence on the first-order resonance frequency f of the refrigerant.

35 [0007] However, since the outlet pipe generally passes through a bottom of the gas-liquid separator, lessening the length of the outlet pipe means that the length of the gas-liquid separator should be also shortened, and thus the capacity of the gas-liquid separator will be reduced, which means the function of the gas-liquid separator will be weakened, causing the possibility of the compressor suffering from liquid hammer to be increased, affecting the performance of the compressor.

40 [0008] In view of this, a Chinese patent with publication No. CN205349734U describes a technical solution in which an outlet pipe passes through a side wall of a housing of a gas-liquid separator to reach the outside of the housing, so that only the length of the outlet pipe is shortened without shortening the length L of the gas-liquid separator, thus not affecting the capacity of the gas-liquid separator. However, it is easy to cause a problem of oil accumulation in an area of the gas-liquid separator below the outlet pipe and reduce the lubricating oil in the compressor, thereby affecting the reliability of the compressor during long-term operation. In addition, since the outlet pipe passes through the side wall of the housing of the gas-liquid separator to reach the outside of the housing, most of the outlet pipe hangs and extends into an inner cavity of the gas-liquid separator, thus causing the outlet pipe to easily produce a relative great vibration when the compressor is operating, causing an increasing in the noise easily, and even causing damage and fracture of the outlet pipe.

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55 SUMMARY

[0009] An objective of the present application is to provide a gas-liquid separator that can improve high frequency

compression performance and facilitate the reflow of lubricating oil.

[0010] To achieve the objective, the present application provides a gas-liquid separator, which includes a housing, an outlet pipe, and a liquid suction pipe. The outlet pipe extends in an inner cavity of the gas-liquid separator, and passes through a side wall of the housing to reach an outside of the housing. One end of the liquid suction pipe extends to a bottom of the inner cavity of the gas-liquid separator, and another end of the liquid suction pipe is connected to the outlet pipe.

[0011] It can be seen from the above that through the arrangement and structural design of the gas-liquid separator in the present application, the outlet pipe passes through the side wall of the housing of the gas-liquid separator to reach the outside of the housing. On the one hand, the present application is beneficial to a lessening of the length of the outlet pipe and an increase in the first-order resonance frequency of the refrigerant, thus preventing the intake frequency of the compressor during high-frequency operation from significantly exceeding the first-order resonance frequency of the refrigerant, so that the first-order resonance frequency of the refrigerant in the gas-liquid separator can be equivalent to the intake frequency of the high-frequency compressor, which is convenient for the compressor to produce the intake pressure boost effect during high-frequency operation, thereby enhancing the intake efficiency of the compressor and improving the performance of the compressor. On the other hand, the arrangement of the liquid suction pipe makes it easy for the lubricating oil at the bottom of the gas-liquid separator to be sucked into the compressor, thereby preventing a large amount of lubricating oil from being accumulated at the bottom of the inner cavity of the gas-liquid separator, enabling the compressor to be lubricated continuously, and ensuring a long-term reliable operation of the compressor.

[0012] According to a preferred solution, the outlet pipe includes an inner extension section and an outer connection section. The inner extension section is disposed in the inner cavity of the gas-liquid separator. The outer connection section passes through the side wall of the housing to reach the outside of the housing. The liquid suction pipe is connected to the outer connection section.

[0013] According to a further solution, the inner extension section extends in a vertical direction.

[0014] According to a further solution, the outer connection section extends in a horizontal direction.

[0015] According to another preferred solution, two outlet pipes are provided. At least one of the outlet pipe passes through the side wall of the housing to reach the outside of the housing.

[0016] According to a further solution, the two outlet pipes pass through the side wall of the housing to reach the outside of the housing.

[0017] According to yet another preferred solution, the outlet pipe passes through a first position of the side wall of the housing to reach the outside of the housing. A distance from the first position to a bottom of the housing is not greater than a distance from the first position to a top of the housing.

[0018] It can be seen from the above that the present application can weaken the vibration of the lower end of the gas-liquid separator and reduce the vibration and noise of the gas-liquid separator.

[0019] According to yet another preferred solution, the gas-liquid separator further includes a fixing member. The fixing member is disposed in the inner cavity of the gas-liquid separator. The fixing member is fixedly connected to the housing and the outlet pipe.

[0020] It can be seen from the above that the present application can reduce the vibration intensity of the outlet pipe.

[0021] According to a further solution, the outlet pipe passes through a first position of the side wall of the housing to reach the outside of the housing. The outlet pipe is connected to the fixing member at a second position. In the vertical direction, the first position is distanced from the second position by a first distance. An end of the outlet pipe extending to a top portion of the inner cavity of the gas-liquid separator is distanced from the first position by a second distance. A ratio of the first distance to the second distance is between 0.3 to 0.7.

[0022] It can be seen from the above that the present application can balance the vibration intensity throughout the outlet pipe, prevent the local severe vibration of the outlet pipe, and prevent local damage to the outlet pipe due to vibration.

[0023] According to yet further preferred solution, a cross-sectional area of the liquid suction pipe is significantly smaller than that of the outlet pipe.

[0024] It can be seen from the above that the present application can prevent a large amount of liquid from flowing into the compressor and prevent the compressor from suffering from liquid hammer. In addition, the compressor is enabled to suck in the lubricating oil through the liquid suction pipe for a long time, which can ensure the long-term reliable operation of the compressor.

[0025] Another objective of the present application is to provide a gas-liquid separator that facilitates the improvement of the high frequency compression performance and the reflow of lubricating oil.

[0026] To achieve the other objective, the present application provides a compressor assembly, which includes a compressor and a gas-liquid separator. The gas-liquid separator includes a housing, an outlet pipe, and a liquid suction pipe. The outlet pipe extends into an inner cavity of the gas-liquid separator, and passes through a side wall of the housing to an outside of the housing. One end of the liquid suction pipe extends to a bottom of the inner cavity of the gas-liquid separator, and another end of the liquid suction pipe is in communication with a fluid inlet of the compressor.

[0027] It can be seen from the above that through the arrangement and structural design of the compressor assembly

in this application, the outlet pipe passes through the side wall of the housing of the gas-liquid separator to reach the outside of the housing. On the one hand, the present application is beneficial to a lessening of the length of the outlet pipe and an increase in the first-order resonance frequency of the refrigerant, thus preventing the intake frequency of the compressor during high-frequency operation from significantly exceeding the first-order resonance frequency of the refrigerant, so that the compressor can utilize the intake pressure boost effect effectively during high-frequency operation, thereby enhancing the intake efficiency of the compressor and improving the performance of the compressor. On the other hand, the arrangement of the liquid suction pipe makes it easy for the lubricating oil at the bottom of the gas-liquid separator to be sucked into the compressor, thereby preventing a large amount of lubricating oil from being accumulated at the bottom of the inner cavity of the gas-liquid separator, enabling the compressor to be lubricated continuously, and ensuring that the long-term reliable operation of the compressor.

[0028] Yet another objective of the present application is to provide a compressor assembly in which the compressor has good high frequency compression performance and facilitates reflow of lubricating oil.

[0029] To achieve the yet other objective, the present application provides a compressor assembly, which includes a compressor and the gas-liquid separator described above. An end of the outlet pipe passing through the housing to reach the outside is connected to the compressor.

[0030] It can be seen from the above that the compressor assembly of the present application adopts the aforementioned gas-liquid separator, so that the intake efficiency of the compressor during high-frequency operation is improved, which makes it easy to improve the high-frequency operation performance of the compressor. In addition, the long-term reliable operation of the compressor can be ensured.

[0031] Yet another objective of the present application is to provide a compressor assembly in which the compressor has good high frequency compression performance and facilitates reflow of lubricating oil.

[0032] To achieve the yet other objective, the present application provides a compressor assembly, which includes a compressor, a connecting member, and the gas-liquid separator described above. The outlet pipe is fixedly connected to the housing at a position where the outlet pipe passes through the housing to reach the outside of the housing. An end of the outlet pipe passing through the housing to reach the outside of the housing is fixedly connected to the compressor. The connecting member is fixedly connected between a casing of the compressor and the housing. In the vertical direction, the outlet pipe is fixedly connected to the housing at a first height position. The fixing member is fixedly connected to the housing at a second height position. The connecting member is fixedly connected to the housing at a third height position. The second height position is between the first height position and the third height position.

[0033] It can be seen from the above that the compressor assembly of the present application adopts the aforementioned gas-liquid separator, so that the intake efficiency of the compressor during high-frequency operation is improved, which makes it easy to improve the high-frequency operation performance of the compressor, thereby ensuring long-term reliable operation of the compressor. In addition, the second height position is provided between the first height position and the third height position, so that the vibration of the inner extension section is transmitted to a portion between the first height position and the third height position of the tubular body through the fixing member, thereby enhancing the connection rigidity of the inner extension section, reducing the vibration intensity of the inner extension section and the vibration intensity of the gas-liquid separator.

[0034] Yet another objective of the present application is to provide an air conditioner in which the compressor has good high frequency compression performance and facilitates reflow of lubricating oil.

[0035] To achieve the yet other objective, the air conditioner according to the present application includes the compressor assembly described above.

[0036] It can be seen from the above that since the compressor assembly of the present application adopts the aforementioned compressor, the intake efficiency of the compressor during high-frequency operation is improved, which improves the high frequency operation performance of the compressor and the high frequency performance of the air conditioner. In addition, the present application can ensure long-term reliable operation of the compressor and facilitates the long-term reliable operation of the air conditioner.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037]

FIG. 1 is a sectional view of a gas-liquid separator in the prior art;
 FIG. 2 is a sectional view of a compressor assembly in the prior art;
 FIG. 3 is a sectional view of a gas-liquid separator according to a first embodiment of the present application;
 FIG. 4 is a sectional view of a compressor assembly according to a first embodiment of the present application;
 FIG. 5 is a sectional view of a gas-liquid separator according to a second embodiment of the present application;
 FIG. 6 is a sectional view of a gas-liquid separator according to a third embodiment of the present application;
 FIG. 7 is a graph showing changes in vibration of a bottom housing of a gas-liquid separator with ratios of H1/H0

according to the present application;

FIG. 8 is a graph showing changes in vibration of a first outlet pipe of a gas-liquid separator with ratios of H3/H2 according to the present application.

5 **[0038]** The application will be further illustrated below by combining with the drawings and embodiments.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0039] First Embodiment of gas-liquid separator, compressor assembly and air conditioner :

10 **[0040]** Referring to FIGS. 3 to 4, an air conditioner of this embodiment is provided with a compressor assembly of this embodiment. The compressor assembly of this embodiment includes a compressor 200 and a gas-liquid separator 100 of this embodiment. The gas-liquid separator 100 of this embodiment includes a housing, a first outlet pipe 103 and a liquid suction pipe 104. The housing includes a tubular body 101 and a bottom housing 105. The bottom housing 105 is fixed to a bottom of the tubular body 101. The first outlet pipe 103 has an inner extension section 131 extending in a vertical direction and an outer connection section 133 extending in a horizontal direction. The inner extension section 131 and the outer connection section 133 are connected by a bent section 132. The inner extension section 131 and the bent section 132 are both disposed in an inner cavity of the gas-liquid separator 100. The inner extension section 131 extends to a top of the inner cavity of the gas-liquid separator 100. The outer connection section 133 passes through a side wall of the tubular body 101 to reach the outside of the housing. The outer connection section 133 is fixed to a casing of the compressor 200 by welding. The outer connection section 133 is fixed to the tubular body 101 by welding. One end of the liquid suction pipe 104 extends to a bottom of the inner cavity of the gas-liquid separator 100, and the other end of the liquid suction pipe 104 is connected to the outer connection section 133.

15 **[0041]** The outer connection section 133 passes through the side wall of the tubular body 101 to reach the outside of the housing, and the inner extension section 131 extends into the inner cavity of the gas-liquid separator 100, therefore the inner extension section 131 is not fixedly connected to the tubular body 101, thus resulting in that the inner extension section 131 is not fixedly positioned, so that the inner extension section 131 may break and be damaged due to vibration. Therefore, a fixing member 102 is fixedly attached to the tubular body 101. The fixing member 102 is disposed in the inner cavity of the gas-liquid separator 100. The fixing member 102 is fixedly connected to the inner extension section of the first outlet pipe 103.

20 **[0042]** The outer connection section 133 passes through the side wall of the tubular body 101 to reach the outside of the shell, which, on the one hand, is beneficial to a lessening of the length of the first outlet pipe 103 and an increase in the first-order resonance frequency of refrigerant in the inner cavity of the gas-liquid separator 100. Therefore, the intake frequency of the compressor during high-frequency operation is prevented from significantly exceeding the first-order resonance frequency of the refrigerant, so that the compressor can effectively use the intake pressure boost effect during high-frequency operation, thereby enhancing intake efficiency of the compressor and improving the performance of the compressor. On the other hand, the arrangement of the liquid suction pipe 104 makes it easy for the lubricating oil at the bottom of the inner cavity of the gas-liquid separator 100 to be sucked into the compressor, thereby preventing a large amount of lubricating oil from being accumulated at the bottom of the inner cavity of the gas-liquid separator 100, enabling the compressor to be lubricated continuously, and ensuring a long-term reliable operation of the compressor.

25 **[0043]** Specifically, referring to FIG. 4, the tubular body 101 is fixed to the casing of the compressor 200 by a connecting member 500. The tubular body 101 and the casing of the compressor 200 are both welded to the connecting member 500. In the vertical direction, the connecting member 500 is disposed above the outer connection section 133. In this case, there are two fixed connections between the tubular body 101 and the casing of the compressor 200, which is beneficial to a more stable and reliable fixed connection between the gas-liquid separator 100 and the compressor 100.

30 **[0044]** In the vertical direction, the outer connection section 133 is fixedly connected to a first height position of the tubular body 101, the fixing member 102 is fixedly connected to a second height position of the tubular body 101, and the connecting member 500 is fixedly connected to a third height position of the tubular body 101. Since the first height position and the third height position of the tubular body 101 are fixedly connected to the casing of the compressor 200, an area between the first height position and the third height position of the tubular body 101 has better anti-vibration performance. Therefore, the second height position is arranged between the first height position and the third height position, so that the vibration of the inner extension section 131 is transmitted to a portion between the first height position and the third height position of the tubular body 101 through the fixing member 102, which is beneficial to an enhancement of the connection rigidity of the inner extension section 131, thereby reducing the vibration intensity of the inner extension section 131 and the vibration intensity of the gas-liquid separator 100.

35 **[0045]** Optionally, the connecting member 500 and the tubular body 101 may also be fixedly connected by one or more manners such as clamping and screwing in addition to welding. Similarly, the connecting member 500 and the casing of the compressor 200 may also be fixedly connected by one or more manners such as clamping and screwing.

40 **[0046]** Optionally, the liquid suction pipe 104 may also be directly connected to a fluid inlet of the compressor in addition

to the outer connection section 133. The liquid suction pipe 104 and the first outlet pipe 103 operate independently.

[0047] Preferably, the inner extension section 131 and the outer connection section 133 are connected by the bent section 132, which can prevent stress from being concentrated at a connecting portion between the inner extension section 131 and the outer connection section 133, and improve the anti-vibration performance of the first outlet pipe 103.

[0048] Specifically, the compressor 200 is a two-cylinder compressor. The gas-liquid separator 100 is further provided with a second outlet pipe. The first outlet pipe 103 and the second outlet pipe 106 each have the inner extension section 131 extending in the vertical direction and the outer connection section 133 extending in the horizontal direction.

[0049] Preferably, the first outlet pipe 103 and the second outlet pipe 106 are both round pipes.

[0050] Referring to FIG. 3, a total height of the housing of the gas-liquid separator 100 is H_0 . A distance from a pipe axis of the outer connection section 133 of the first outlet pipe 103 to a bottom of the bottom housing 105 is H_1 . A distance from the pipe axis of the outer connection section 133 of the first outlet pipe 103 to a top of the inner extension section 131 of the first outlet pipe 103 is H_2 . A distance from the pipe axis of the outer connection section 133 of the first outlet pipe 103 to the fixing member 102 is H_3 .

[0051] A top of the second outlet pipe 106 is flush with the top of the first outlet pipe 103. The outer connection section 133 of the second outlet pipe 106 is disposed below the outer connection pipe of the first outlet pipe 103. A distance from the pipe axis of the outer connection section 133 of the second outlet pipe 106 to the pipe axis of the outer connection section 133 of the first outlet pipe 103 is H_4 .

[0052] Since the outer connection section 133 passes through the side wall of the tubular body 101 to reach the outside of the housing, the outer connection section 133 is fixed to the tubular body 101 at the position which the outer connection section 133 passes through, and the outer connection section 133 is no longer fixed to the bottom housing 105 of the gas-liquid separator 100. The bottom housing 105 of the gas-liquid separator 100 is prone to larger vibrations. In order to reduce the vibration intensity of the bottom housing 105 of the gas-liquid separator 100, in this embodiment, the maximum vibration value of the bottom housing 105 of the gas-liquid separator 100 is simulated by an Ansys simulation software under different conditions where H_1/H_0 is within a range from 0.2 to 0.7. The maximum vibration value of the bottom housing 105 of the gas-liquid separator 100 corresponding to $H_1/H_0=0.5$ is used as a reference. Specifically, when $H_1/H_0=0.5$, the relative value of the maximum vibration value b of the bottom housing 105 of the gas-liquid separator 100 is set to 1, and the maximum vibration value a of the bottom housing 105 of the gas-liquid separator 100 corresponding to H_1/H_0 of another value is divided by the maximum vibration value b of the bottom housing 105 of the gas-liquid separator 100 when $H_1/H_0=0.5$, to obtain a/b . The value of a/b is a relative vibration value of the bottom housing 105 of the gas-liquid separator 100 corresponding to H_1/H_0 of the other value. A graph of the relative vibration values of the bottom housing 105 of the gas-liquid separator 100 corresponding to different conditions where H_1/H_0 is within the range from 0.2 to 0.7 is drawn and shown in FIG. 7.

[0053] As shown in FIG. 7, when $H_1/H_0=0.4$, the vibration of the bottom housing 105 of the gas-liquid separator 100 is the weakest. When H_1/H_0 is greater than 0.5, the vibration of the bottom housing 105 of the gas-liquid separator 100 increases sharply, thus H_1/H_0 is limited to be not greater than 0.5. As the value of H_1/H_0 decreases, a length L_1 of the first outlet pipe 103 will increase accordingly. Therefore, more preferably, H_1/H_0 is limited to be between 0.4 and 0.5. In this way, the relationship between the length L_1 of the first outlet pipe 103 and the vibration intensity of the bottom housing 105 of the gas-liquid separator 100 can be balanced as much as possible, which is not only beneficial for the compressor to utilize the intake pressure boost effect, but also improves the performance of the compressor and reduces the vibration of the gas-liquid separator 100 as much as possible, thereby reducing noise generated when the compressor is operating.

[0054] The farther a position is away from the position where the first outlet pipe 103 is fixed, the more drastic the vibration. In order to determine the optimal position of the fixed member 102, in this embodiment, the maximum vibration values of the top of the inner extension section 131 and the bent section 132 are simulated by the Ansys simulation software under different conditions where H_3/H_2 is within the range from 0.1 to 0.9. When $H_3/H_2=0.7$, the maximum vibration value of the top of the inner extension section 131 is used as a reference. Specifically, when $H_3/H_2=0.7$, the relative value of the maximum vibration value d of the top of the inner extension section 131 is set to 1, and the maximum vibration value of the top of the inner extension section 131 corresponding to H_3/H_2 of another value, or the bent section 132 is c , then a value of c/d is the relative vibration value of the top of the inner extension section 131 or the bent section 132 corresponding to H_3/H_2 . A graph of the relative vibration values of the top of the inner extension section 131 or the bent section 132 under different conditions where H_3/H_2 is within the range from 0.1 to 0.9 is drawn and shown in FIG. 8.

[0055] As shown in FIG. 8, as the ratio of H_3/H_2 increases, the relative vibration value of the top of the inner extension section 131 continuously decreases. In an interval where H_3/H_2 is less than 0.3, the relative vibration value of the top of the inner extension section 131 decreases at a faster rate. As the ratio of H_3/H_2 increases, the vibration value of the bent section 132 continuously increases, and the vibration of the bent section 132 increases faster when H_3/H_2 is greater than 0.7. Therefore, H_3/H_2 is limited to be between 0.3 and 0.7, which not only prevents the sharp increase in the vibration of the top of the inner extension section 131, but prevents the sharp increase in the vibration of the bent section 132.

[0056] In this embodiment, the parameters of the gas-liquid separator 100 and the compressor 200 are as follows: $H_0=235\text{mm}$; $H_1=80\text{mm}$; $H_2=120\text{mm}$; $H_3=47\text{mm}$; $H_4=32\text{mm}$; a cross-sectional area A_1 of a single pipe is equal to 201mm^2 ; a length L_1 of the first outlet pipe 103 is equal to 188mm ; a length L_2 of the second outlet pipe 106 is equal to 252mm ; a displacement V_1 of a single compression cylinder is equal to 22cm^3 ; and a transmission speed C of the sound in the refrigerant is equal to 228m/s . According to the parameters of the first outlet pipe 103, the intake resonance frequency f_1 is calculated, to obtain $f_1=228/\{4[0.188+22/201]\}=192\text{ s}^{-1}$. According to the parameters of the second outlet pipe 106, the intake resonance frequency f_2 in the gas-liquid separator 100 is calculated, to obtain $f_2=228/\{4[0.252+22/201]\}=158\text{ s}^{-1}$. Therefore, the intake resonance frequency in the gas-liquid separator 100 should be between 158 s^{-1} and 192 s^{-1} . The intake resonance frequency in the gas-liquid separator 100 is approximately 175 s^{-1} (namely, $(192+158)/2=175\text{ s}^{-1}$).

[0057] Referring to FIGS. 1 and 2, in a two-cylinder compressor in the prior art, a gas-liquid separator 300 includes a third outlet pipe 303 and a fourth outlet pipe 306. The third outlet pipe 303 and the fourth outlet pipe 306 both pass through a bottom housing of a gas-liquid separator 300 to reach the outside of the housing, and then are fixedly connected to a casing of a compressor 400. A total height of a housing of the gas-liquid separator 300 is H_5 . A distance from a pipe axis of an outer connection section 333 of the third outlet pipe 303 to a bottom of the bottom housing is H_6 . A distance from the pipe axis of the outer connection section 333 to a top of an inner extension section 331 of the third outlet pipe 303 is H_7 . A distance from the pipe axis of the outer connection section 333 of the third outlet pipe 303 to a fixing member 102 is H_8 .

[0058] Atop of the fourth outlet pipe 306 is flush with the top of the third outlet pipe 303. An outer connection section of the fourth outlet pipe 306 is disposed below the outer connection section 333 of the third outlet pipe 303. A pipe axis of the outer connection section of the fourth outlet pipe 306 is distanced from the pipe axis of the outer connection section 333 of the third outlet pipe 303 by H_9 .

[0059] In the prior art, the parameters of the gas-liquid separator 300 and the compressor are as follows: $H_5=180\text{mm}$; $H_6=55.5\text{mm}$; $H_7=200\text{mm}$; $H_8=152\text{mm}$; $H_9=32\text{mm}$; a cross-sectional area A_2 of a single pipe is equal to 201mm^2 ; a length L_3 of the third outlet pipe 303 is equal to 268mm ; a length L_4 of the fourth outlet pipe 306 is equal to 332 ; a displacement V_2 of a single compression cylinder is equal to 22cm^3 ; and a transmission speed C of the sound in the refrigerant is equal to 228m/s . According to the parameters of the third outlet pipe 303, the intake resonance frequency f_3 is calculated, to obtain $f_3=228/\{4[0.268+22/201]\}=151\text{s}^{-1}$. According to the parameters of the fourth outlet pipe 306, the intake resonance frequency f_4 in the gas-liquid separator 300 is calculated, to obtain $f_4=228/\{4[0.332+22/201]\}=129\text{s}^{-1}$. Therefore, the intake resonance frequency in the gas-liquid separator 300 should be between 129 s^{-1} and 151s^{-1} . The intake resonance frequency in the gas-liquid separator 300 approximates to 140s^{-1} (namely, $(129+151)/2=140\text{s}^{-1}$).

[0060] In this case, if the compressor operates at an intake frequency of 180Hz , the following data can be obtained through testing:

	Solution of This Embodiment	Scheme in Prior Art
Effective volume of the gas-liquid separator (cc)	860	640
intake resonance frequency $f(\text{s}^{-1})$	Between 158 to 192	Between 129 to 151
Volume efficiency of the compressor (%)	114.7	93.2
Vibration of the gas-liquid separator 100 (m/s^2)	24.1	37.7
Noise (dB)	78.3	81.5

[0061] Through comparing the scheme in the prior art with the technical solution of this embodiment, it can be seen from the above table that the effective volume of the gas-liquid separator 100 of the technical solution of this embodiment is significantly larger than that of the gas-liquid separator 300 in the prior art, and the volumetric efficiency of the compressor is significantly improved, and the vibration and the noise of the gas-liquid separator 100 in the technical solution of this embodiment are significantly weaker than those of the gas-liquid separator 300 in the prior art.

[0062] Second Embodiment of Gas-liquid separator, compressor assembly, and air conditioner :

[0063] As shown in FIG. 5, the first outlet pipe 103 passes through the side wall of the tubular body 101 to reach the outside of the housing, and the second outlet pipe 106 passes through the bottom housing 105 to reach the outside of the housing, which can also shorten the lengths of the first outlet pipe 103 and the second outlet pipe 103, and increase the intake resonance frequency in the inner cavity of the gas-liquid separator 100.

[0064] Other components of the gas-liquid separator, the compressor assembly, and the air conditioner of the second embodiment are the same as those of the gas-liquid separator, the compressor assembly, and the air conditioner of the first embodiment.

[0065] Third Embodiment of Gas-liquid separator, compressor assembly, and air conditioner:

[0066] As shown in FIG. 6, in this embodiment, the gas-liquid separator 100 is provided with only the first outlet pipe 103. The gas-liquid separator 100 of this embodiment is used for a single-cylinder compressor.

[0067] The other components of the gas-liquid separator, the compressor assembly, and the air conditioner of the third embodiment are the same as those of the gas-liquid separator, the compressor assembly, and the air conditioner of the first embodiment.

[0068] Finally, it should be emphasized that the above descriptions only illustrate preferred embodiments of the present application, and are not intended to limit the present application. For those skilled in the art, the present application can have various variants and changes. Any modification, equivalent replacement, improvement, etc. made within the spirit and the principle of the present application, shall be included in the scope of protection of the present application.

Claims

1. A gas-liquid separator, comprising a housing and an outlet pipe, **characterized in that**,
 - the outlet pipe extends in an inner cavity of the gas-liquid separator, and passes through a side wall of the housing to reach an outside of the housing;
 - the gas-liquid separator further comprises a liquid suction pipe; one end of the liquid suction pipe extends to a bottom of the inner cavity of the gas-liquid separator, and another end of the liquid suction pipe is connected to the outlet pipe.
2. The gas-liquid separator according to claim 1, **characterized in that**, the outlet pipe comprises an inner extension section and an outer connection section; the inner extension section is disposed in the inner cavity of the gas-liquid separator; the outer connection section passes through the side wall of the housing to reach the outside of the housing; and the liquid suction pipe is connected to the outer connection section.
3. The gas-liquid separator according to claim 2, **characterized in that**, the inner extension section extends in a vertical direction.
4. The gas-liquid separator according to claim 2, **characterized in that**, the outer connection section extends in a horizontal direction.
5. The gas-liquid separator according to any one of claims 1 to 4, **characterized in that**, two outlet pipes are provided, at least one of the outlet pipes passes through the side wall of the housing to reach the outside of the housing.
6. The gas-liquid separator according to claim 5, **characterized in that**, the two outlet pipes pass through the side wall of the housing to reach the outside of the housing.
7. The gas-liquid separator according to any one of claims 1 to 4, **characterized in that**, the outlet pipe passes through a first position of the side wall of the housing to reach the outside of the housing; a distance from the first position to a bottom of the housing is not greater than a distance from the first position to a top of the housing.
8. The gas-liquid separator according to any one of claims 1 to 4, **characterized by**, further comprising a fixing member; wherein the fixing member is disposed in the inner cavity of the gas-liquid separator; and the fixing member is fixedly connected to the housing and the outlet pipe.
9. The gas-liquid separator according to claim 8, **characterized in that**, the outlet pipe passes through a first position of the side wall of the housing to reach the outside of the housing; the outlet pipe is connected to the fixing member at a second position; in the vertical direction, the first position is distanced from the second position by a first distance; an end of the outlet pipe extending to a top portion of the inner cavity of the gas-liquid separator is distanced from the first position by a second distance; a ratio of the first distance to the second distance is between 0.3 to 0.7.
10. A compressor assembly, **characterized by** comprising a compressor and a gas-liquid separator,
 - wherein the gas-liquid separator comprises a housing, an outlet pipe, and a liquid suction pipe;

the outlet pipe extends into an inner cavity of the gas-liquid separator, and passes through a side wall of the housing to an outside of the housing;

one end of the liquid suction pipe extends to a bottom of the inner cavity of the gas-liquid separator, and another end of the liquid suction pipe is in communication with a fluid inlet of the compressor.

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11. A compressor assembly, **characterized by** comprising a compressor, and the gas-liquid separator according to any one of claims 1 to 7, wherein an end of the outlet pipe passing through the housing to reach the outside is connected to the compressor.

10 12. A compressor assembly, **characterized by** comprising a compressor, and a connecting member, and the gas-liquid separator according to claim 8 or 9, wherein the outlet pipe is fixedly connected to the housing at a position where the outlet pipe passes through the housing to the outside; an end of the outlet pipe passing through the housing to the outside is fixedly connected to the compressor; the connecting member is fixedly connected between a casing of the compressor and the housing;

15 in the vertical direction, the outlet pipe is fixedly connected to the housing at a first height position; the fixing member is fixedly connected to the housing at a second height position; the connecting member is fixedly connected to the housing at a third height position; the second height position is between the first height position and the third height position.

20 13. An air conditioner, **characterized by** comprising the compressor assembly according to claim 11.

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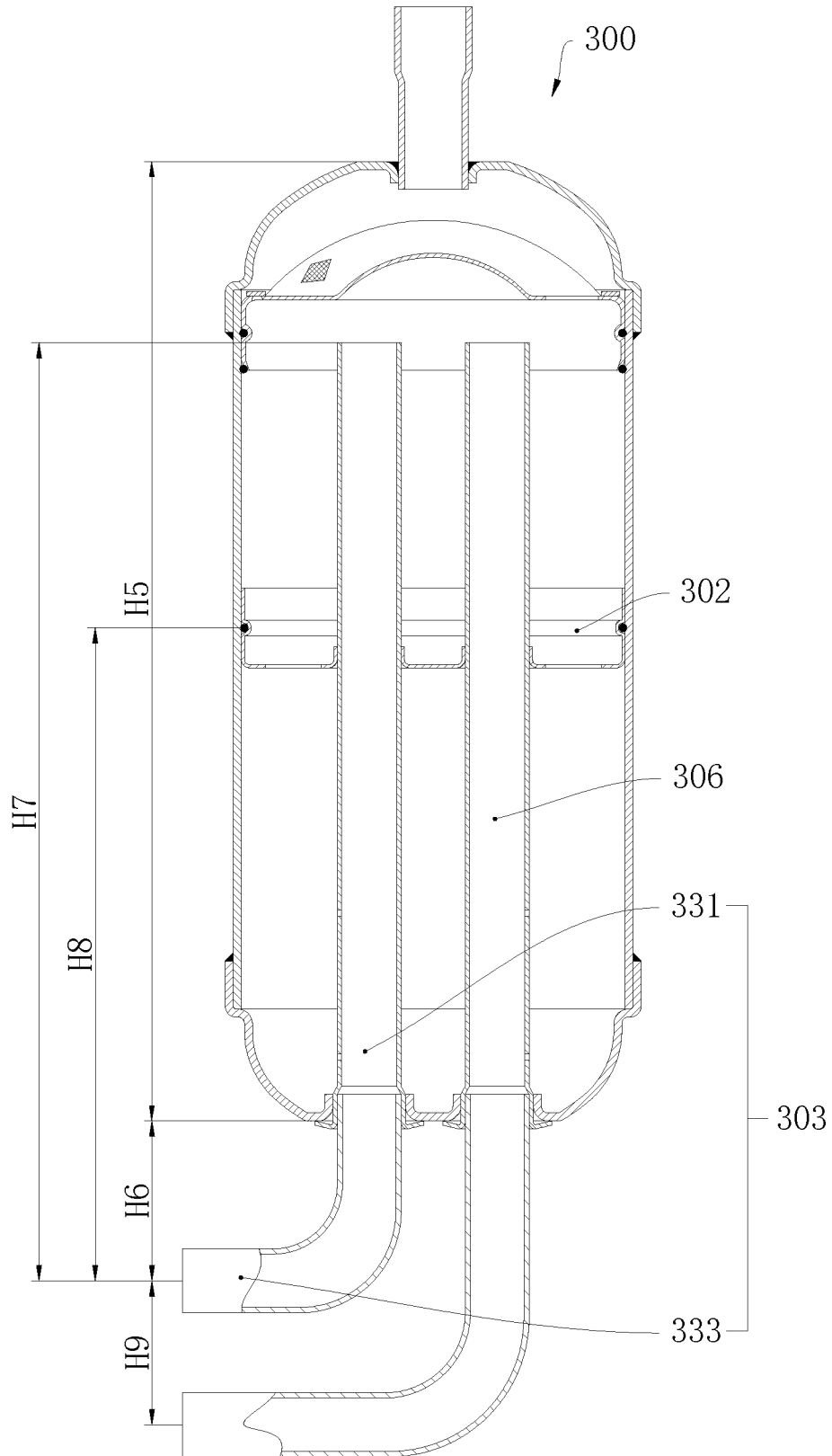


FIG. 1

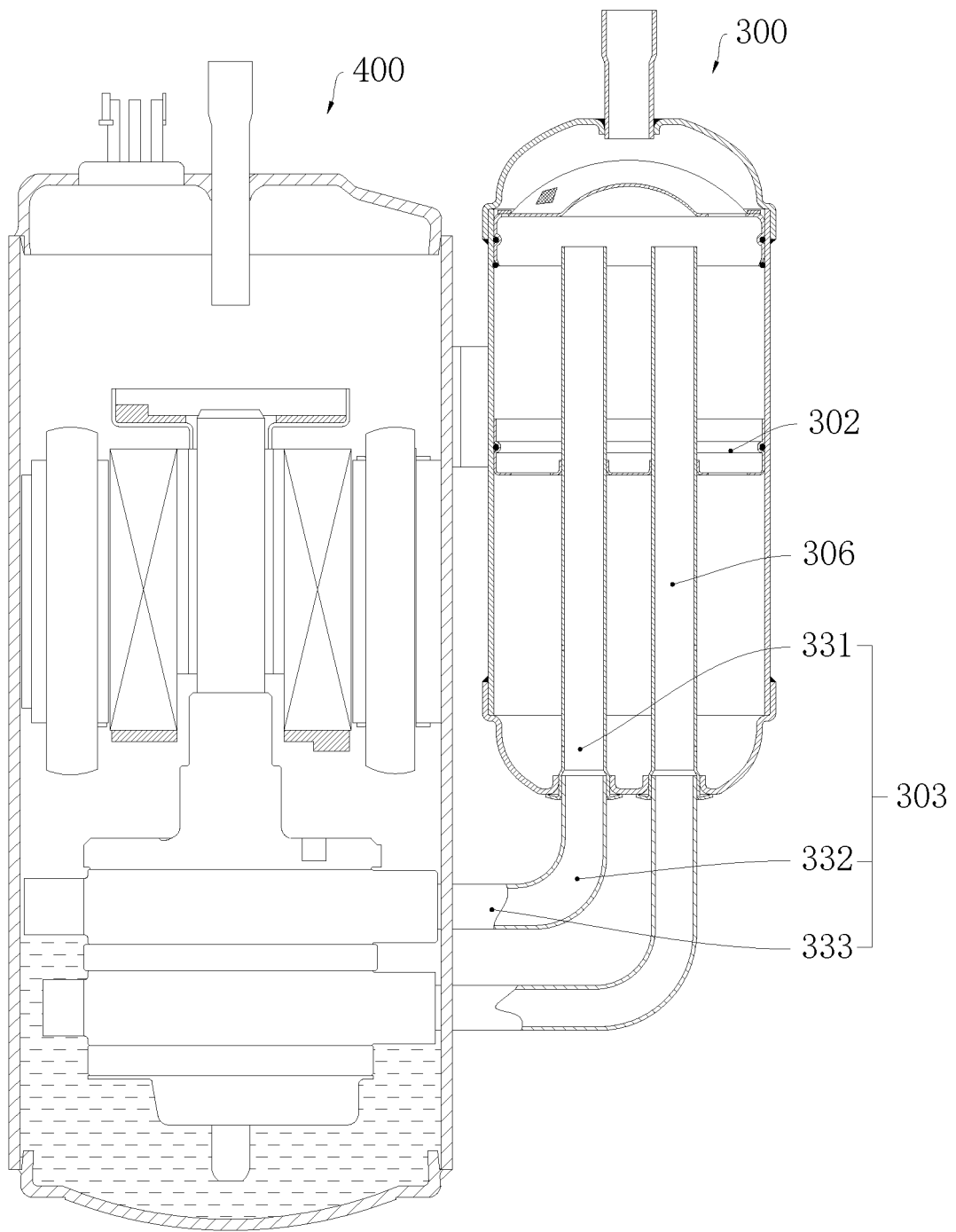


FIG. 2

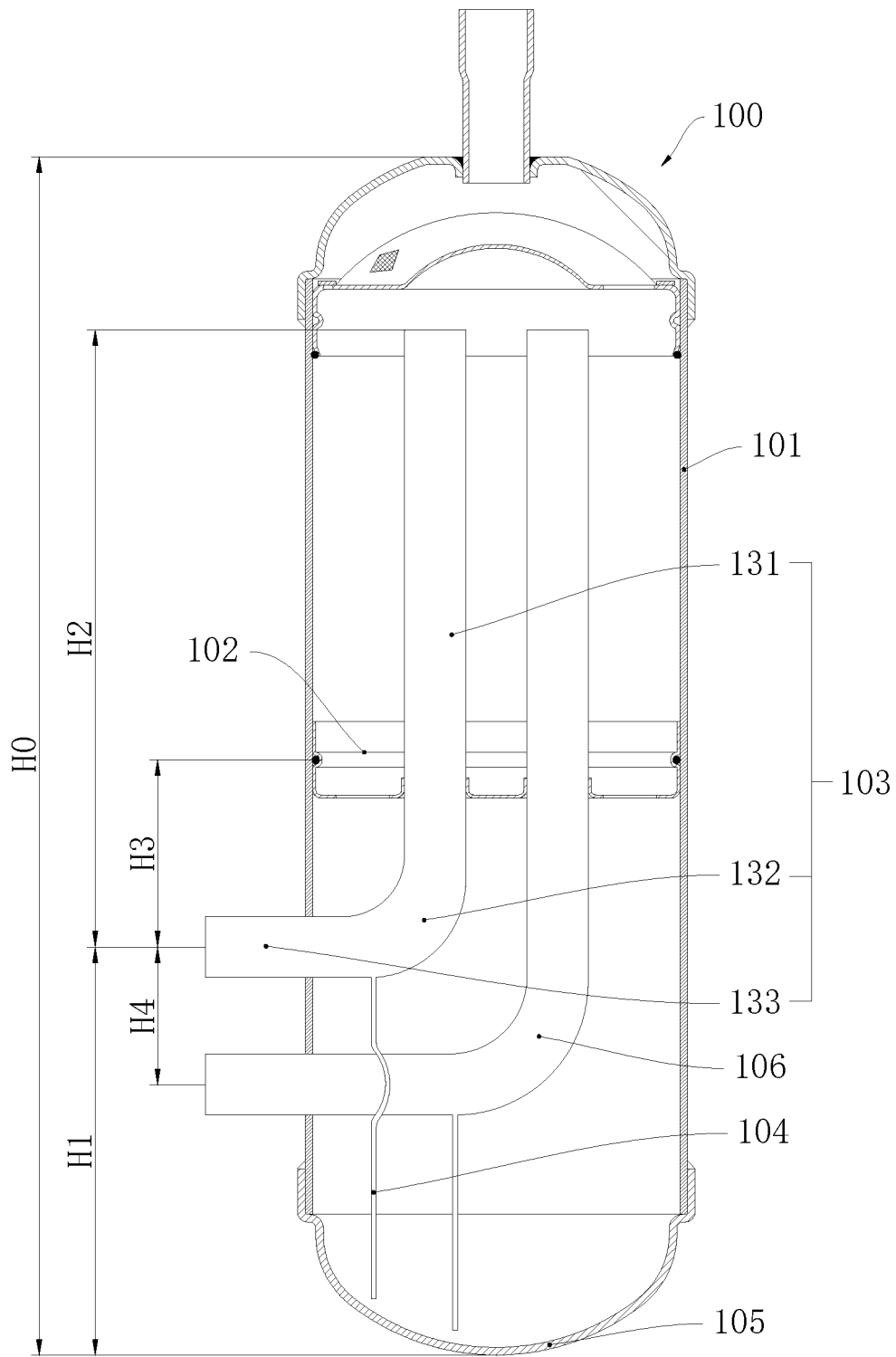


FIG. 3

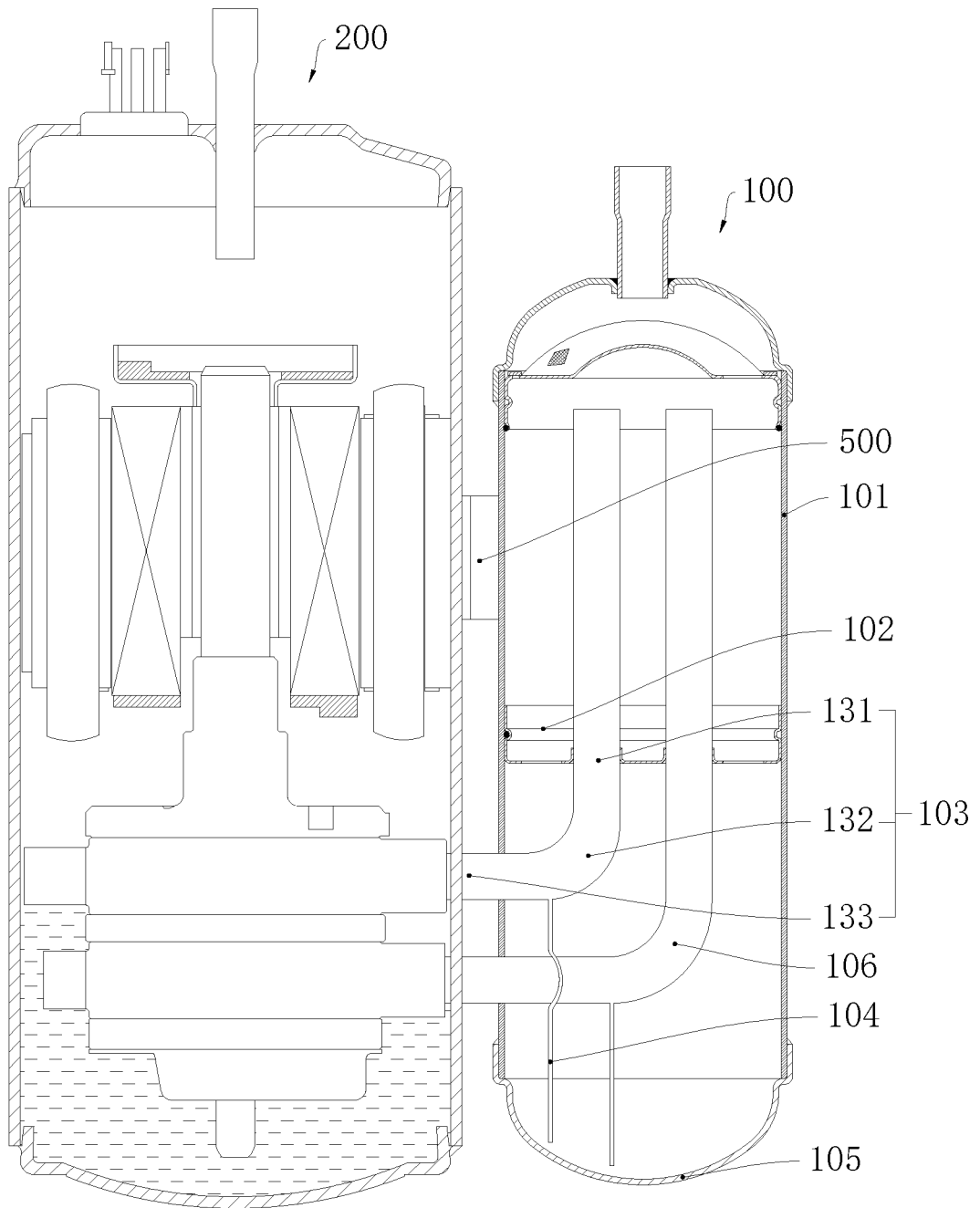


FIG. 4

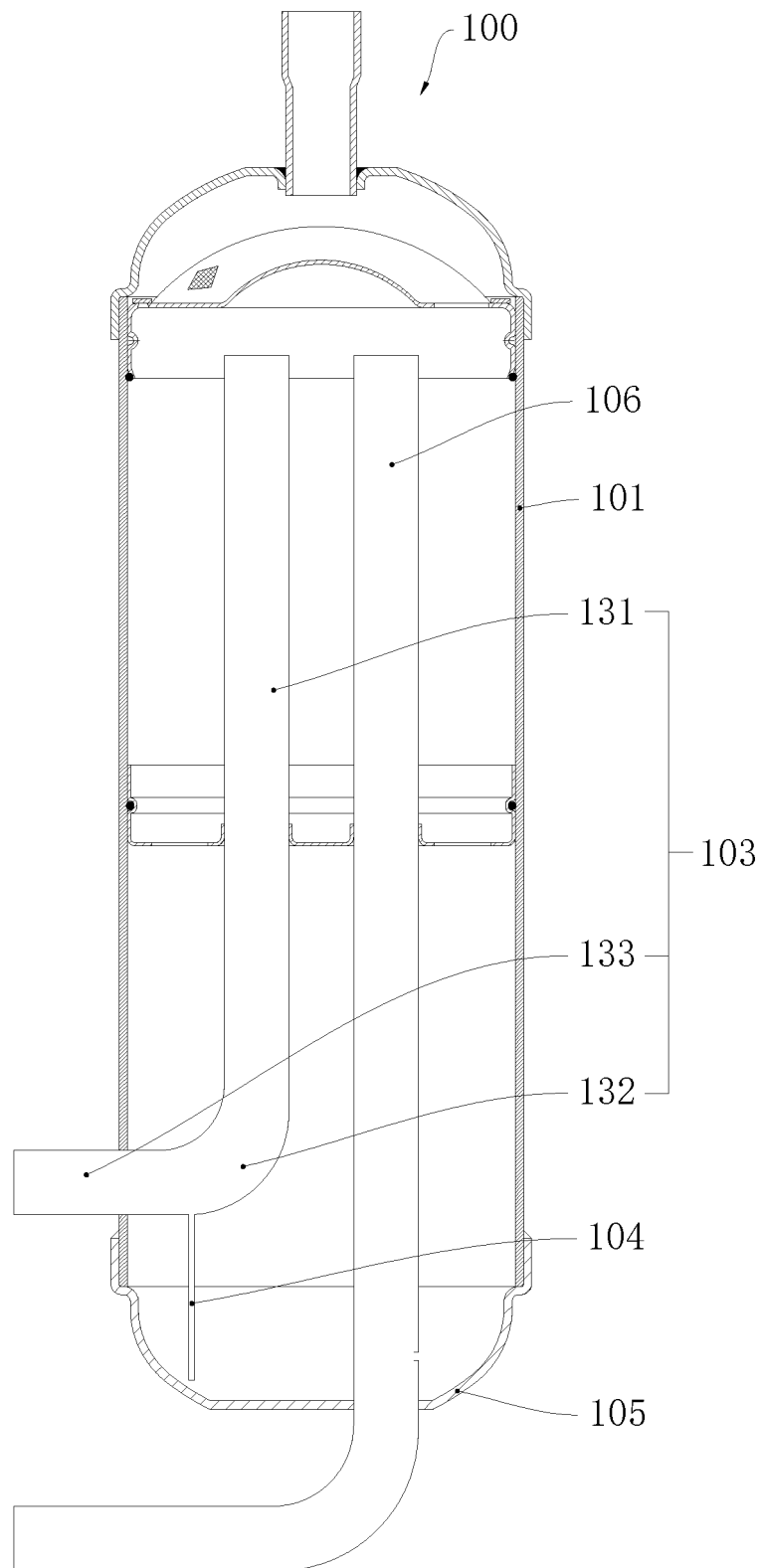


FIG. 5

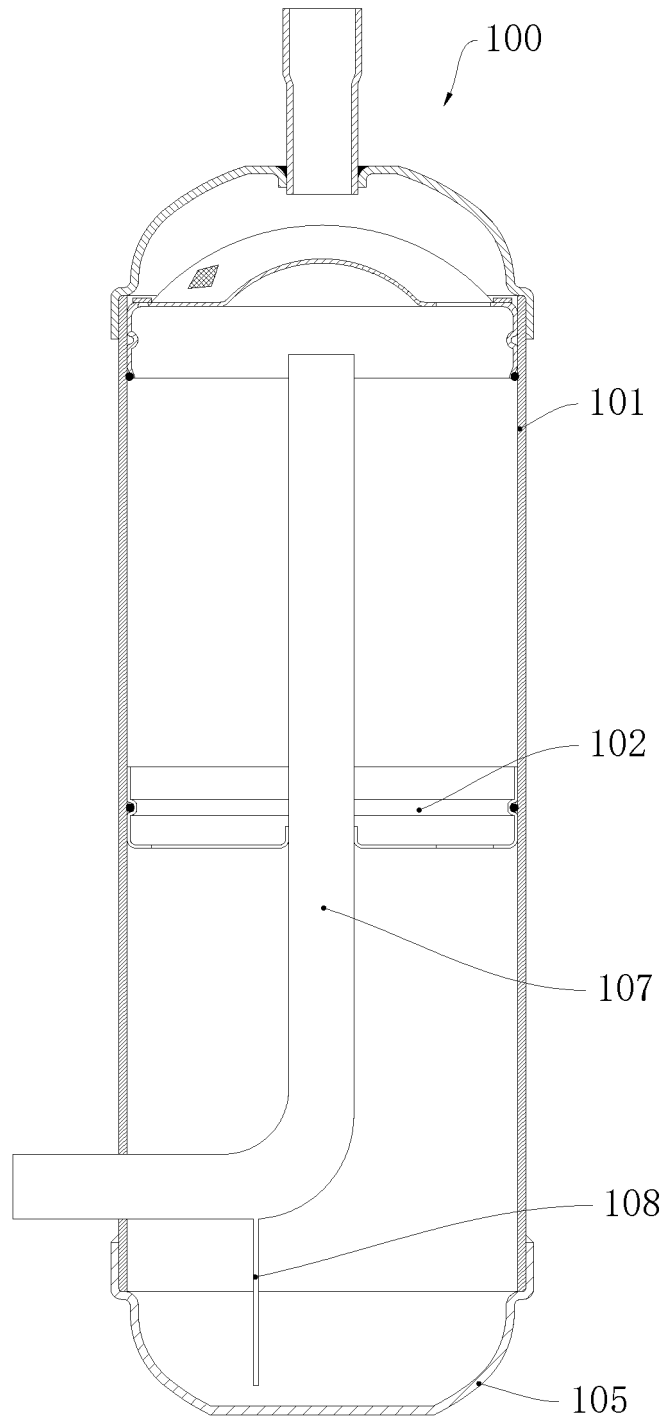


FIG. 6

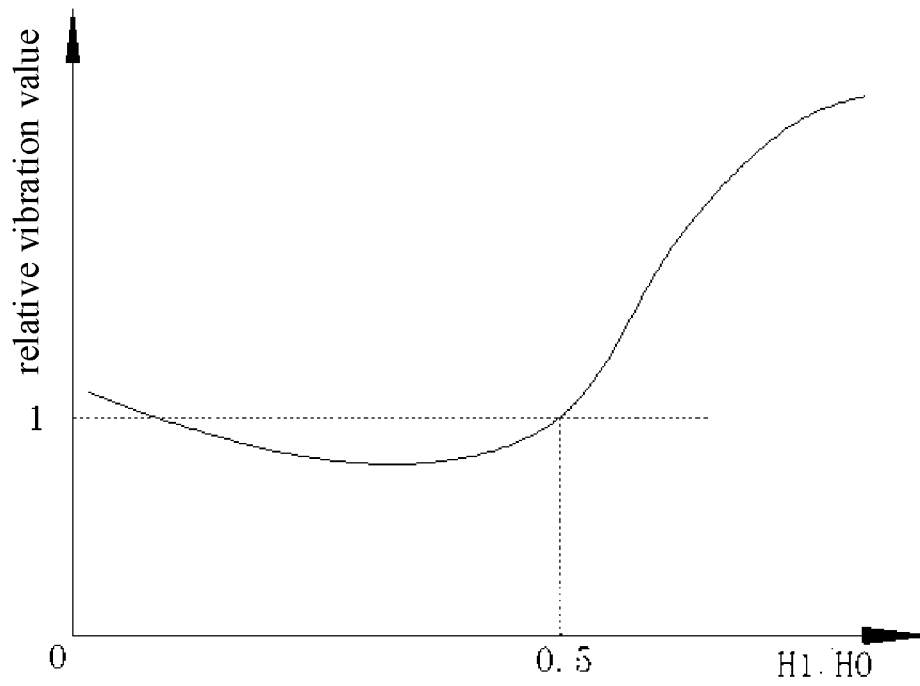


FIG. 7

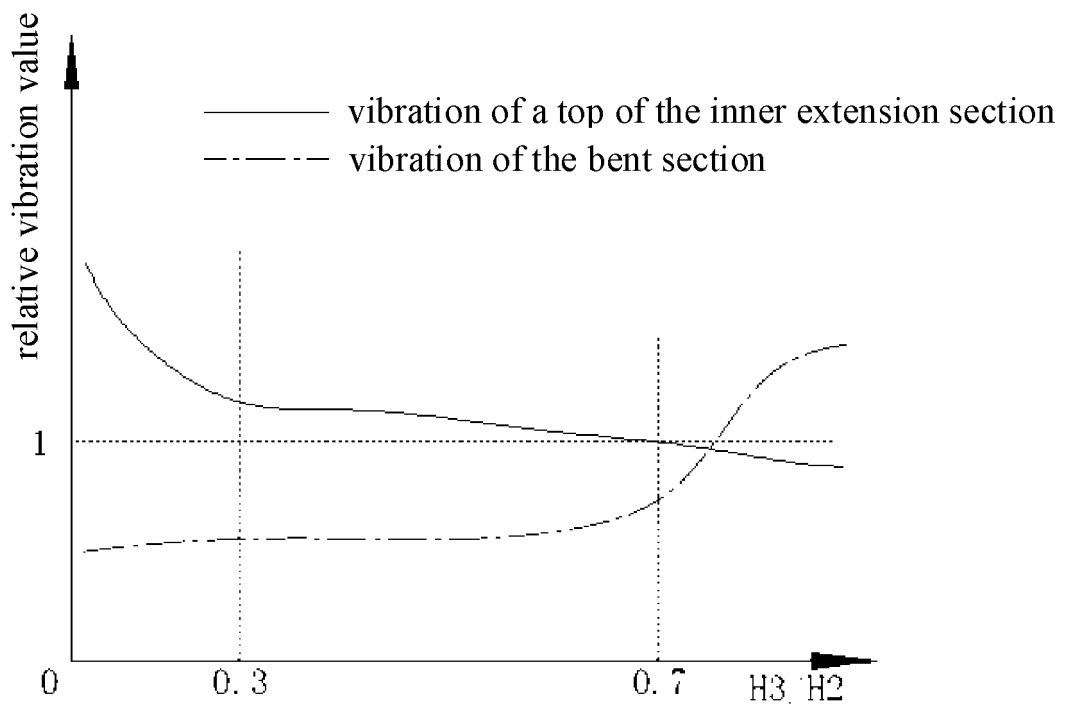


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2019/110745

5	A. CLASSIFICATION OF SUBJECT MATTER F25B 43/00(2006.01)i; F25B 31/00(2006.01)i; F04C 29/12(2006.01)i According to International Patent Classification (IPC) or to both national classification and IPC	
10	B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) F25B F04C Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched	
15	Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) CNABS; DWPI; SIPOABS; CNKI: 压缩机, 气液分离, 出液管, 出口管, 输出管, 中间, 侧面, 中部, 侧壁, 吸液管, compressor, outlet tube, outlet pipe, gas liquid separat+, middle, lateral	
20	C. DOCUMENTS CONSIDERED TO BE RELEVANT	
25	Category*	Citation of document, with indication, where appropriate, of the relevant passages
30	X	JP 2014092078 A (DAIKIN INDUSTRIES LTD.) 19 May 2014 (2014-05-19) description, paragraphs [0007]-[0066], and figures 1-4
35	Y	JP 2014092078 A (DAIKIN INDUSTRIES LTD.) 19 May 2014 (2014-05-19) description, paragraphs [0007]-[0066], and figures 1-4
40	Y	JP 2004360622 A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 24 December 2004 (2004-12-24) description, paragraphs [0013]-[0030], and figures 1-5
45	A	JP 2011174401 A (PANASONIC CORP.) 08 September 2011 (2011-09-08) entire document
50	A	JP 2011179394 A (PANASONIC CORP.) 15 September 2011 (2011-09-15) entire document
55	A	JP 2011047546 A (PANASONIC CORP.) 10 March 2011 (2011-03-10) entire document
	A	CN 106091498 A (ZHEJIANG XINCHANG SANRUI HORNSEY STAMPING INDUSTRY CO., LTD.) 09 November 2016 (2016-11-09) entire document
	<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.	
	* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family
	Date of the actual completion of the international search 06 December 2019	Date of mailing of the international search report 30 December 2019
	Name and mailing address of the ISA/CN China National Intellectual Property Administration (ISA/CN) No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088 China Facsimile No. (86-10)62019451	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2019/110745

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C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2012026496 A1 (MITSUBISHI ELECTRIC CORP. et al.) 01 March 2012 (2012-03-01) entire document	1-13
PX	CN 109945559 A (GREE ELECTRIC APPLIANCES, INC. OF ZHUHAI et al.) 28 June 2019 (2019-06-28) claims 1-13	1-13

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2019/110745

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JP	2004360622	A	24 December 2004		None			
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JP	2011179394	A	15 September 2011		None			
JP	2011047546	A	10 March 2011		None			
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					JP	WO2012026496	A1	28 October 2013
CN	109945559	A	28 June 2019		None			

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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